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High-intensity running in English FA Premier League soccer matches

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Abstract

The aims of this study were to (1) determine the activity profiles of a large sample of English FA Premier League soccer players and (2) examine high-intensity running during elite-standard soccer matches for players in various playing positions. Twenty-eight English FA Premier League games were analysed during the 2005–2006 competitive season ($n = 370$), using a multi-camera computerised tracking system. During a typical match, wide midfielders (3138 m, $s = 565$) covered a greater distance in high-intensity running than central midfielders (2825 m, $s = 473$, $P = 0.04$), full-backs (2605 m, $s = 387$, $P < 0.01$), attackers (2341 m, $s = 575$, $P < 0.01$), and central defenders (1834 m, $s = 256$, $P < 0.01$). In the last 15 min of a game, high-intensity running distance was ~20% less than in the first 15-min period for wide midfielders (467 m, $s = 104$ vs. 589 m, $s = 134$, $P < 0.01$), central midfielders (429 m, $s = 106$ vs. 534 m, $s = 99$, $P < 0.01$), full-backs (389 m, $s = 95$ vs. 481 m, $s = 114$, $P < 0.01$), attackers (348 m, $s = 105$ vs. 438 m, $s = 129$, $P < 0.01$), and central defenders (276 m, $s = 93$ vs. 344 m, $s = 80$, $P < 0.01$). There was a similar distance deficit for high-intensity running with (148 m, $s = 78$ vs. 193 m, $s = 96$, $P < 0.01$) and without ball possession (229 m, $s = 85$ vs. 278 m, $s = 97$, $P < 0.01$) between the last 15-min and first 15-min period of the game. Mean recovery time between very high-intensity running bouts was 72 s ($s = 28$), with a 28% longer recovery time during the last 15 min than the first 15 min of the game (83 s, $s = 26$ vs. 65 s, $s = 20$, $P < 0.01$). The decline in high-intensity running immediately after the most intense 5-min period was more evident in attackers (216 m, $s = 50$ vs. 113 m, $s = 47$, $P < 0.01$) and central defenders (182 m, $s = 26$ vs. 96 m, $s = 39$, $P < 0.01$). The results suggest that high-intensity running with and without ball possession is reduced during various phases of elite-standard soccer matches and the activity profiles and fatigue patterns vary among playing positions. The current findings provide valuable information about the high-intensity running patterns of a large sample of elite-standard soccer players, which could be useful in the development and prescription of specific training regimes.

Keywords: *ProZone, high-intensity running, recovery time, fatigue, playing position*

Introduction

Findings from time–motion studies are useful for quantifying the physiological demands of soccer and can provide the conceptual framework for the development of specific performance tests and training regimes (Bangsbo, Nørregaard, & Thorsøe, 1991; Drust, Reilly, & Cable, 2000; Drust, Reilly, & Rienzi, 1998). Researchers have examined the activity patterns of Australian (Withers, Maricic, Wasilewski, & Kelly, 1982), Belgian (Van Gool, Van Gerven, & Boutmans, 1988), Canadian (Mayhew and Wenger, 1985), Danish (Bangsbo et al., 1991; Mohr, Krustrup, & Bangsbo, 2003), Swedish (Andersson, Ekblom, & Krustrup, 2007), Japanese (Ohashi, Togari, Isokawa, & Suzuki, 1988), Italian (Mohr et al., 2003), and Spanish League soccer players (Di Salvo et al., 2007). However, there is limited information on movement patterns of contemporary elite-standard English League soccer players. Studies conducted to date have used small sample sizes (Rienzi, Drust, Reilly, Carter, & Martin, 2000; Strudwick and Reilly, 2001) or were performed more than 30 years ago (Reilly & Thomas, 1976). Therefore, a study using a large sample of players could provide a more accurate depiction of the current demands of the elite-standard English League, since there is variability in movement patterns both among and within players according to match and playing position (Bangsbo, 1994; Mohr et al., 2003).

Some researchers have suggested that distances covered during high-intensity running in matches are valid measures of physical performance in soccer

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because of their strong relationship with training status (Krustrup et al., 2003; Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005) and are a distinguishing characteristic between different standards of player (Bangsbo et al., 1991; Mohr et al., 2003). Recent findings using computerised time–motion analysis of elite-standard Italian League soccer players demonstrated that high-intensity running was reduced towards the end of the game and temporarily after intense periods of the game (Mohr, Krustrup, & Bangsbo, 2003, 2005). Mohr et al. (2003) did not investigate the extent to which temporary and end-game fatigue occurred for players in various playing positions. In addition, it is unclear whether decrements in high-intensity running towards the end of the game are with or without ball possession. Detailed examination of high-intensity running by position in 5-min periods of multiple matches would provide valuable information regarding patterns of within-game fatigue. Such detailed analyses could also be used to provide information regarding differences in high-intensity running in the most intense periods of play and recovery times after very high-intensity running bouts. Finally, quantifying players' maximal running speeds could provide insight into any fatigue-related changes in high-speed performance during matches and positional variations in speed profiles.

Therefore, the aims of the present study were to (1) determine the activity profiles of a large sample of English FA Premier League soccer players and (2) examine high-intensity running during elite-standard soccer matches for players in various playing positions.

Methods

Match analysis

With institutional ethics approval, 28 English FA Premier League games were analysed during the 2005–2006 competitive season, using a multi-camera computerised tracking system (ProZone Version 3.0, ProZone Sports Ltd®, Leeds, UK). All outfield players' movements were captured during each game by eight colour cameras (Vicon surveyor dome SVFT-W23, Oxford, UK) positioned in each of the stadiums at roof height (Figure 1). During the installation process, each camera's position, zoom, and field of vision were fixed to guarantee the long-term stability of the capture system. The position of the cameras allowed the complete playing area to be covered from all corners of the stadium to address issues of accuracy, occlusion, resilience, and resolution. Furthermore, to facilitate the tracking of each player, every section of the playing area was covered by at least two cameras. The data captured were analysed using match-analysis software (Stadium Manager, ProZone Sports Ltd®, Leeds, UK) to produce a single data set on each player's activity pattern during a match. Signals received from the cameras were digitised at a sampling frequency of 10 Hz. This system has recently been independently validated to verify the capture process and subsequent accuracy of the data (Di Salvo, Collins, McNeill, & Cardinale, 2006).

The games selected for analysis were played between teams of a similar placing in the league table and at a similar time of day to minimise the influence of circadian variations on performance (Reilly & Brooks, 1986). To avoid indirect comparisons with playing time, only data from players completing an entire match were used. This allowed profiling of 370 players in various playing positions (92 central defenders, 84 full-backs, 80 central midfielders, 52 wide midfielders, and 62 attackers). Furthermore, to ensure team and player confidentiality, all data were desensitised before analysis.

Movement categories and speed thresholds

Players' activities were coded into the following categories and speed thresholds: standing (0–0.6 km · h^{-1}), walking (0.7–7.1 km · h^{-1}), jogging (7.2–14.3 km · h^{-1}), running (14.4–19.7 km · h^{-1}), high-speed running (19.8–25.1 km · h^{-1}), and sprinting ($>$25.1 km · h^{-1}). High-intensity running consisted of running, high-speed running, and sprinting (running speed $>$14.4 km · h^{-1}). Very high-intensity running consisted of high-speed running and sprinting (running speed $>$19.8 km · h^{-1}). The speed thresholds for each category are similar to those reported previously (Bangsbo et al., 1991; Mohr et al., 2003; Rampinini, Coutts, Castagna, Sassi, & Impellizzeri, 2007). High-intensity running with ball possession was defined as the high-intensity running distance covered when the players' own team was in possession of the ball. High-intensity running without ball possession was defined as the subtraction of high-intensity running distance with possession of the ball from total high-intensity running distance. Peak high-intensity running distance represented the 5 min that contained most high-intensity running in a match and was specific for each player profiled (Mohr et al., 2003). Distance covered, frequency of occurrence, and time spent in each category were obtained at 5-, 15-, and 45-min time periods. Mean recovery time was defined as the time that elapsed between very high-intensity running bouts (running speed $>$19.8 km · h^{-1}). Maximal running speed was defined as the top speed a player reached in 5-min periods of a match.

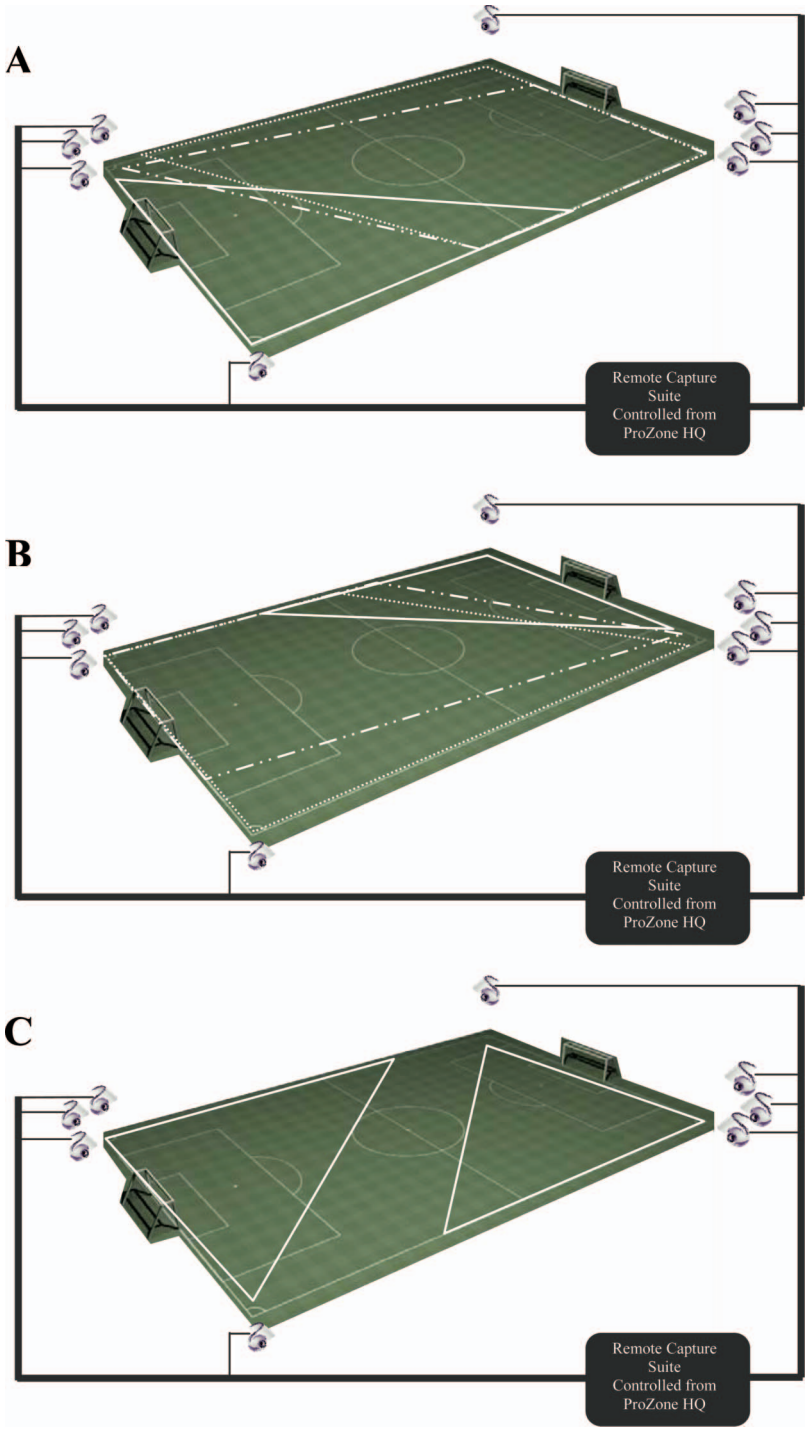

Figure 1. The ProZone® capture system uses eight colour cameras that cover the entire pitch from all four corners of the stadium: (A) cameras 1–3 positioned in corner 1; (B) cameras 4–6 positioned in corner 2; (C) cameras 7 and 8 positioned opposite one another.

Inter- and intra-observer reliability

An intra- and inter-observer reliability study was conducted using five players (two central defenders, two central midfielders, and one attacker) from a randomly selected English FA Premier League game. Two trained observers tracked each player on two separate occasions, interspersed by 7 days, and coefficients of variation were determined to assess reliability (Atkinson & Nevill, 1998). The intra-observer coefficients of variation for total distance covered, walking, running, high-speed running, high-intensity running, very high-intensity running, and sprinting were 1.0, 0.9, 1.2, 1.6, 1.1, 1.8, and 2.4%, respectively. The inter-observer coefficients of variation for total distance covered, walking, running, high-speed running, high-intensity running, and very high-intensity running were $<2\%$ with

the exception of sprinting, which was 3.5%. These values compare favourably with those reported by Impellizzeri and colleagues (Impellizzeri, Sassi, & Rampinini, 2006) for similar computerised tracking systems used in soccer.

Statistical analyses

All statistical analyses were conducted using SPSS for Windows Version 14.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were calculated on each variable and *z*-scores were used to verify normality. Differences between the first and second half were determined using paired sample *t*-tests. Differences between 5-, 15-, and 45-min periods within a match were determined using one-way analysis of variance (ANOVA) with repeated measures. In the event of a significant difference, Tukey's *post-hoc* tests were used to identify any localised effects. Statistical significance was set at $P < 0.05$. Data are presented as means and standard deviations unless otherwise stated.

Results

Activity profile

During matches, players stood for 5.6% ($s = 2.4$) of the total time. Low-intensity activity represented 85.4% of total time, which consisted of 59.3% ($s = 4.8$) walking and 26.1% ($s = 3.8$) jogging. High-intensity runs represented 9.0% of total time, which consisted of 6.4% ($s = 1.6$) running, 2.0% ($s = 0.6$) high-speed running, and 0.6% ($s = 0.2$) sprinting. Players spent longer standing and walking in the second than the first half (standing: 181 s, $s = 81$ vs. 148 s, $s = 70$, $P < 0.01$; walking: 1739 s, $s = 143$ vs. 1674 s, $s = 150$, $P < 0.01$). More time was spent jogging and running in the first than the second half (jogging: 769 s, $s = 109$ vs. 723 s, $s = 126$, $P < 0.01$; running: 192 s, $s = 51$ vs. 179 s, $s = 56$, $P < 0.01$). There was no difference in time spent in high-speed running or sprinting between the two halves (high-speed running: 58 s, $s = 19$ vs. 56 s, $s = 18$, $P = 0.06$; sprinting: 16 s, $s = 8$ vs. 17 s, $s = 9$, $P = 0.07$). Players performed more bouts of high-intensity running in the first than the second half (279, $s = 66$ vs. 267, $s = 67$, $P < 0.01$). No differences were observed for sprint frequency between the two halves (17, $s = 8$ vs. 18, $s = 9$, $P = 0.56$).

Distances covered

Mean total distance covered during a match was 10,714 m ($s = 991$). The distance covered during the first half was greater than during the second half of a match (5422 m, $s = 561$ vs. 5292 m, $s = 508$, $P < 0.01$). Greater distances were covered in the first half than the second half when jogging (2172 m, $s = 338$ vs. 2052 m, $s = 315$, $P < 0.01$) and running (879 m, $s = 237$ vs. 827 m, $s = 221$, $P < 0.01$), whereas the distance covered when walking was greater in the second than in the first (1929 m, $s = 145$ vs. 1889 m, $s = 183$, $P < 0.01$). There were no differences between first and second half distance for high-speed running (326 m, $s = 111$ vs. 336 m, $s = 114$, $P = 0.98$) and sprinting (123 m, $s = 59$ vs. 132 m, $s = 68$, $P = 0.06$).

High-intensity profile

Mean distances covered in high-intensity running and very high-intensity running were 2492 m ($s = 625$) and 905 m ($s = 285$). Distance covered in high-intensity running was 17% less in the last 15 min of the first half and 21% less in the last 15 min of the second half than in the first 15-min period of the game (391 m, $s = 131$ and 374 m, $s = 119$ vs. 466 m, $s = 137$, $P < 0.01$) (Figure 2). The distance covered by players when sprinting was lower in the last 15-min versus the first 15-min period in both the first (34 m, $s = 23$ vs. 43 m, $s = 17$, $P = 0.02$) and second half (36 m, $s = 20$ vs. 44 m, $s = 19$, $P = 0.02$). The distance covered in high-intensity running with possession of the ball in the last 15-min period of the game was 23% less than in the first 15-min period (148 m, $s = 78$ vs. 193 m, $s = 96$ m, $P < 0.01$) (Figure 3).

Peak distance covered in high-intensity running in a 5-min period was 231 m ($s = 53$). In the subsequent 5-min period, the amount of high-intensity running was 126 m ($s = 52$), which was 6% less than the mean distance covered during all 5-min periods minus the peak 5-min period (134 m, $s = 35$,

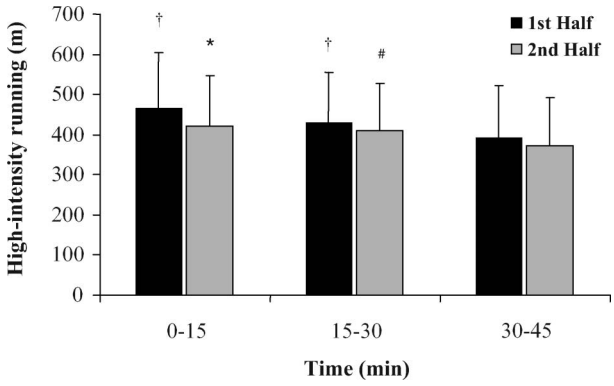

Figure 2. Distance covered in high-intensity running by players during the first and second half within 15-min periods of match-play. Significant difference between first and second half: $^{*}P < 0.01$; $^{\#}P < 0.05$. †Different from last 15 min ($P < 0.05$). Values are means and standard deviations.

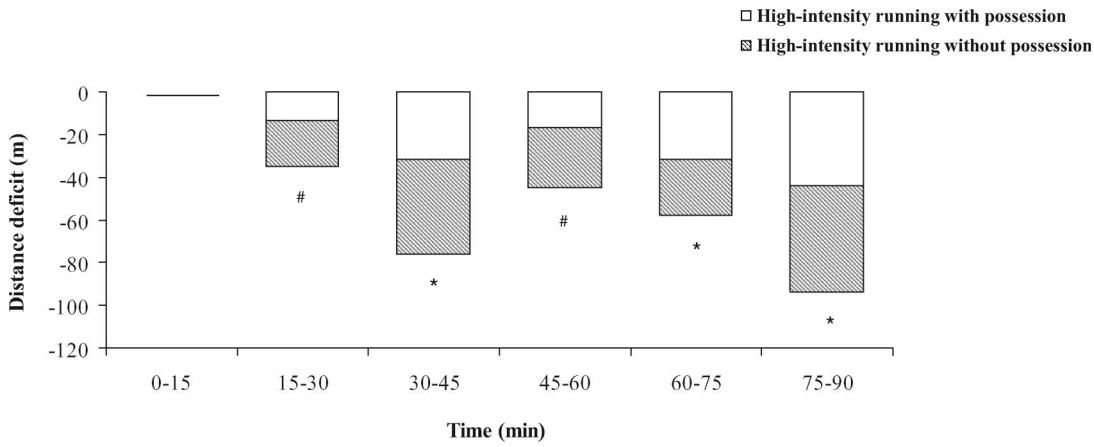

Figure 3. Contribution of high-intensity running with and without the ball to the high-intensity distance deficit during match-play. High-intensity running distances with and without the ball were different from the first 15-min values at all time periods: $^{*}P < 0.01$; $^{\#}P < 0.05$.

$P = 0.03$) (Figure 4). When peak distance covered in high-intensity running was analysed in each half, high-intensity running in a 5-min period was 213 m ($s = 54$) and 210 m ($s = 52$) for first and second half respectively. In the subsequent 5-min period, the amount of high-intensity running was 126 m ($s = 48$) and 122 m ($s = 49$) for the first and second half respectively, which was 7% and 6% less than the mean high-intensity distance covered during all 5-min periods in each half minus the peak 5-min period (136 m, $s = 37$ and 130 m, $s = 34$, $P = 0.01$).

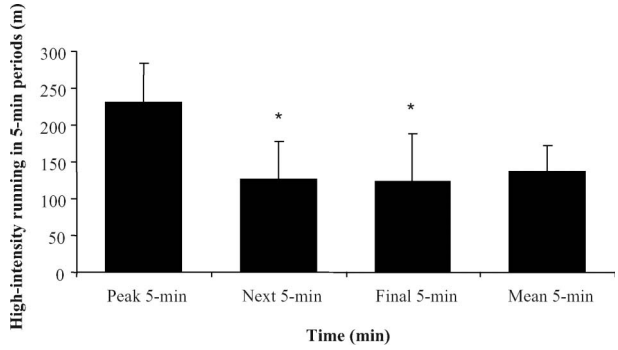

Figure 4. Peak high-intensity running distance covered by players in 5-min periods, next 5-min, final 5-min, and mean values of the remaining 5-min periods minus the peak value. *Different from mean 5-min period ($P < 0.05$). Values are means and standard deviations.

Recovery time and maximal running speed

Mean recovery time between very high-intensity running bouts was 72 s ($s = 28$). Recovery times during the second half were 15% longer than in the first half (77 s, $s = 25$ vs. 67 s, $s = 23$, $P = 0.01$) and 28% longer during the last 15 min than the first 15 min of the game (83 s, $s = 26$ vs. 65 s, $s = 20$, $P < 0.01$). Moreover, players' recovery time increased over the duration of each half, with longer ($P = 0.01$) recovery times found for the second 5-min period and in particular the last five 5-min periods of the first half and the last three 5-min periods of the second half compared with the first 5-min period (Figure 5).

Maximal running speeds during the second half were not different from the first half (7.64 m $\cdot$ s^{-1}, $s = 0.40$ vs. 7.62 m $\cdot$ s^{-1}, $s = 0.44$, $P = 0.58$). The maximum running speeds were lower during the last 15 min of the first half (7.51 m $\cdot$ s^{-1}, $s = 0.61$, $P = 0.01$) but not the second half (7.59 m $\cdot$ s^{-1}, $s = 0.61$, $P = 0.29$) versus the first 15-min period of the game (7.65 m $\cdot$ s^{-1}, $s = 0.56$).

Positional differences

Wide and central midfielders covered a greater total distance ($P < 0.01$) than full-backs, attackers, and central defenders (Table I). Wide midfielders also covered a greater distance in high-intensity running ($P < 0.01$) than central defenders, full-backs, central midfielders, and attackers. Central defenders undertook less ($P < 0.01$) high-intensity running than all other positions. Wide midfielders and full-backs covered a greater ($P < 0.01$) distance when sprinting than central midfielders, attackers, and central defenders. The attackers demonstrated no significant decline in high-intensity running distance ($P = 0.10$), whereas central defenders and full-backs showed a greater decline ($P < 0.05$) from the first to the second half than central and wide midfielders (Figure 6). Distances covered in high-intensity running in the last 15 min of the game were 21, 20, 19, 21, and 20% less than in the first 15-min period for wide midfielders (467 m, $s = 104$ vs. 589 m, $s = 134$, $P < 0.01$), central midfielders (429 m, $s = 106$ vs. 534 m, $s = 99$, $P < 0.01$), full-backs (389 m, $s = 95$ vs. 481 m, $s = 114$, $P < 0.01$), attackers (348 m, $s = 105$ vs. 438 m, $s = 129$,

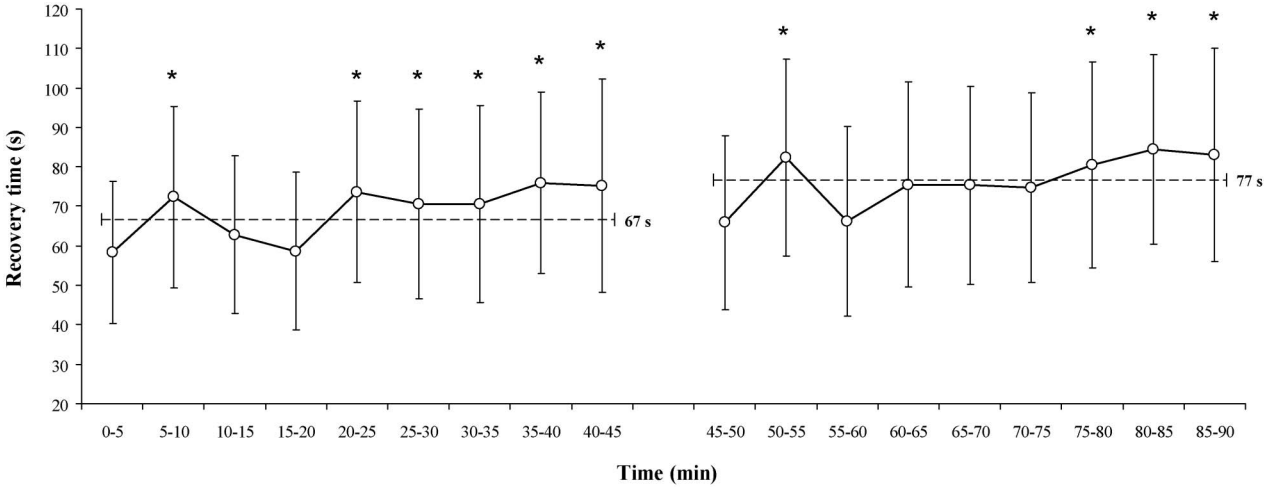

Figure 5. Mean recovery time between very high-intensity bouts (running speed >19.8 km $\cdot$ h^{-1}) attained in 5-min periods of match-play. *Different from first 5 min of each half ($P < 0.01$). #Different from the first 5 min of each half ($P < 0.05$). Broken line denotes mean values over a 45-min period. Values are means and standard deviations.

Table I. Match performance variables in relation to playing position.

Match performance variables	Central defenders ($n = 92$)	Full-backs ($n = 84$)	Central midfielders ($n = 80$)	Wide midfielders ($n = 52$)	Attackers ($n = 62$)
Distances covered					
Total (m)	9885 ± 555	10710 ± 589	11450 ± 608[a]	11535 ± 933[a]	10314 ± 1175
High-intensity running (m)	1834 ± 256	2605 ± 387	2825 ± 473	3138 ± 565[b]	2341 ± 575
Very high-intensity running (m)	603 ± 132	984 ± 195	927 ± 245	1214 ± 251[b]	955 ± 239
Sprinting (m)	152 ± 50	287 ± 98[c]	204 ± 89	346 ± 115[c]	264 ± 87
Other variables					
Maximal running speed (m $\cdot$ s^{-1})	7.31 ± 0.30	7.74 ± 0.24[d]	7.52 ± 0.32	7.93 ± 0.31[d]	7.76 ± 0.28[d]
Recovery time (s)	101 ± 15	74 ± 23	62 ± 19[a]	51 ± 16[a]	73 ± 22

Notes: [a]Different from central defenders, full-backs, and attackers ($P < 0.05$). [b]Different from all other playing positions ($P < 0.05$). [c]Different from central defenders, central midfielders, and attackers ($P < 0.01$). [d]Different from central defenders and central midfielders ($P < 0.05$).

$P < 0.01$), and central defenders (276 m, $s = 93$ vs. 344 m, $s = 80$, $P < 0.01$).

The decline in high-intensity running immediately after the most intense 5-min period was more evident in central defenders (182 m, $s = 26$ vs. 96 m, $s = 39$ or 47%, $P < 0.01$) and attackers (216 m, $s = 50$ vs. 113 m, $s = 47$ or 48%, $P < 0.01$) than full-backs (243 m, $s = 39$ vs. 137 m, $s = 53$ or 44%, $P < 0.01$), wide midfielders (282 m, $s = 49$ vs. 162 m, $s = 56$ or 43%, $P < 0.01$), and central midfielders (251 m, $s = 46$ vs. 137 m, $s = 50$ or 45%, $P < 0.01$). However, there was no difference in the relative decline in high-intensity running between positions. Wide and central midfielders demonstrated less recovery time ($P < 0.01$) between very high-intensity running bouts than full-backs, attackers, and central defenders.

Wide midfielders, attackers, and full-backs also demonstrated a higher maximal running speed in the first 15-min period of the game than central midfielders (wide midfielders: 7.98 m $\cdot$ s^{-1}, $s = 0.38$, $P < 0.01$; attackers: 7.81 m $\cdot$ s^{-1}, $s = 0.58$, $P < 0.01$; full-backs: 7.70 m $\cdot$ s^{-1}, $s = 0.49$, $P = 0.02$; central defenders: 7.61 m $\cdot$ s^{-1}, $s = 0.57$). This was also the case in the final 15-min period of the first half (wide midfielders: 7.80 m $\cdot$ s^{-1}, $s = 0.50$, $P < 0.01$; attackers: 7.57 m $\cdot$ s^{-1}, $s = 0.51$, $P = 0.03$; full-backs: 7.81 m $\cdot$ s^{-1}, $s = 0.54$, $P < 0.01$; central midfielders: 7.33 m $\cdot$ s^{-1}, $s = 0.60$) and second half (wide midfielders: 7.93 m $\cdot$ s^{-1}, $s = 0.61$, $P < 0.01$; attackers: 7.77 m $\cdot$ s^{-1}, $s = 0.44$, $P = 0.01$; full-backs: 7.62 m $\cdot$ s^{-1}, $s = 0.65$, $P = 0.04$; central midfielders: 7.32 m $\cdot$ s^{-1}, $s = 0.59$) (Figure 7). Maximal running speed over the course of the game was higher ($P < 0.05$) for wide midfielders, attackers, and full-backs than central midfielders and central defenders.

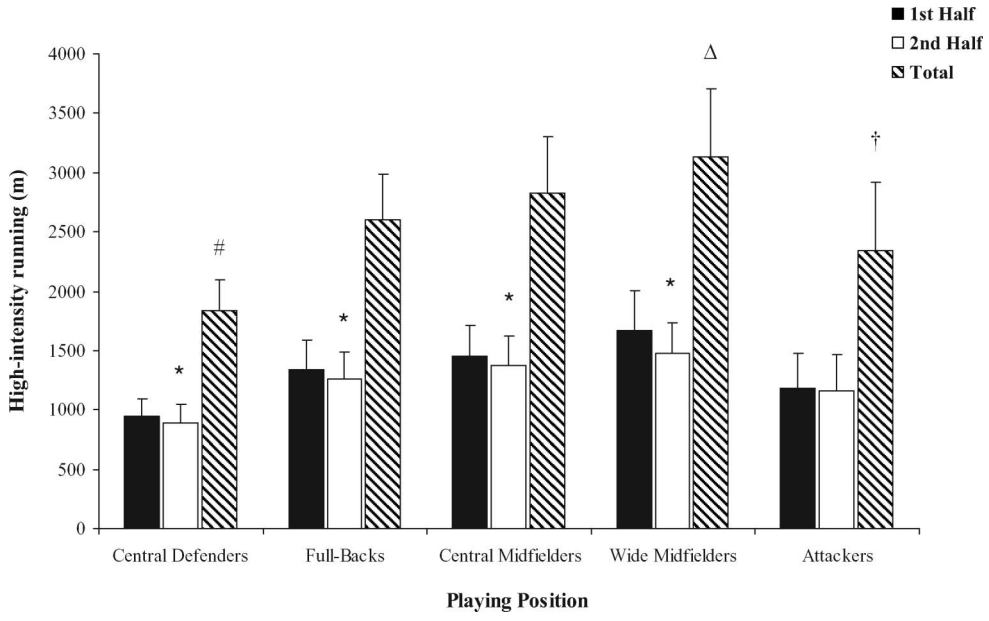

Figure 6. High-intensity running in each half and during the entire game for various playing positions. *Difference between the first and second half ($P < 0.05$). #Different from full-backs, central midfielders, wide midfielders, and attackers. †Different from central midfielders and wide midfielders ($P < 0.05$). ΔDifferent from central defenders, central midfielders, full-backs, and attackers ($P < 0.05$). Values are means and standard deviations.

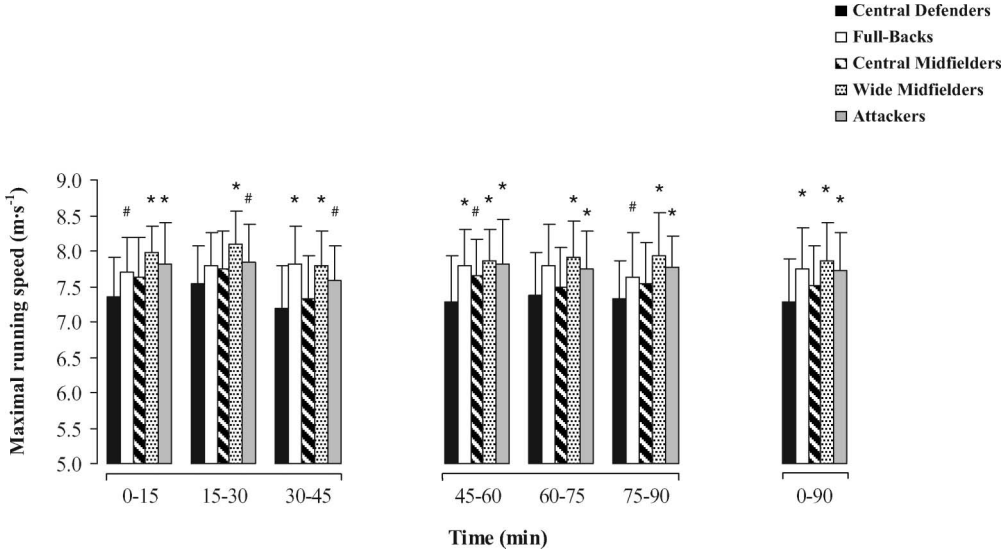

Figure 7. Mean maximal running speeds for players in various playing positions within 15-min periods and during the entire match. Different from central defenders: *$P < 0.01$; #$P < 0.05$. Values are means and standard deviations.

Discussion

The results of this study provide evidence of the high physical demands of the modern elite-standard English League and that the amounts of high-intensity running of central and wide midfielders, full-backs, and central defenders, but not attackers, are comparable to recent results obtained from elite-standard Italian and Spanish Leagues. Despite large positional differences in high-intensity running, the pattern of high-intensity running changed after the most intense periods and towards the end of the game for players in all playing positions. The mean recovery time between very high-intensity running bouts increased markedly over the duration of the game, resulting in an end-game ''distance deficit'' of ~20% for high-intensity running with and without ball possession. After the most intense 5-min period, high-intensity running was reduced by ~50% to levels below the game mean, due to fewer and shorter high-intensity running bouts.

Using a large sample of English FA Premier League players representing all playing positions, the results show that high-intensity running and total distance covered were higher for wide (3138 and 11,535 m) and central midfielders (2825 and 11,450 m) than for full-backs (2605 and 10,710 m), attackers (2341 and 10,314 m), and central defenders (1834 and 9885 m). Furthermore, it was observed that wide midfielders, full-backs, and attackers cover a greater distance when sprinting (346, 287, and 264 m, respectively) than central midfielders (204 m) and central defenders (152 m). These data show that the total distances covered in the modern elite-standard English League are much higher than 30 years ago (Reilly & Thomas, 1976), but also reveal that the amount of high-intensity running is similar to the Italian Serie A and the Spanish Primera Division (Di Salvo et al., 2007; Mohr et al., 2003). The category for high-intensity running used in the present study (>14.4 km $\cdot$ h^{-1}) can be used for a direct comparison with recent studies using similar categories (>15 km $\cdot$ h^{-1}, Mohr et al., 2003; >14.1 km $\cdot$ h^{-1}, Di Salvo et al., 2007). Strikingly similar values for high-intensity running were obtained for elite-standard English and Spanish League central defenders (1834 vs. 1869 m), full-backs (2605 vs. 2784 m), wide midfielders (3138 vs. 3171 m), and central midfielders (2825 vs. 2991 m), whereas the English League attackers performed less high-intensity running than their Spanish counterparts (2341 vs. 2708 m). Mean values for high-intensity running of 2430 m in the Italian Serie A (Mohr et al., 2003) are also close to the mean values obtained in the present study. Furthermore, the present data suggest that the amount of high-intensity running is 10–15% higher in the English FA Premier League than in the Danish (Mohr et al., 2003) and Swedish Premier Leagues (Andersson et al., 2007). It should be noted that different methods of observation and variations in the classification of movements may account for differences between studies for high-intensity running. However, tactical and physical reasons may explain the increased intensity in the modern English League and the differences in high-intensity running performed by the English League attackers compared with attackers in other elite-standard European leagues. Evidence for increased intensity during modern English soccer is further supported by a quantitative comparative analysis of English League matches played in the 1991–1992 and 1997–1998 seasons (Williams, Lee, & Reilly, 1999). Matches played in the 1997–1998 season included more dribbling, passing, running with possession of the ball, and crosses. The differences in high-intensity running between the present study and the Danish (Mohr et al., 2003) and Swedish Premier Leagues (Andersson et al., 2007) could be attributed to differences in playing style. In the English game, players are required to maintain a high level of activity when not directly involved in play to create space to receive passes or to pressurise opponents into making mistakes in order to regain possession. Furthermore, it has been speculated that the fitness level of attackers are not sufficient to meet the demands of elite-standard European leagues. In support of this notion, attackers performed more poorly in the game-specific Yo-Yo intermittent recovery test (IR) 1 and 2 (Krustrup et al., 2003, 2006). In the combined aerobic and anaerobic Yo-Yo IR2 test, they performed poorer than players in all other playing positions, including central defenders. Further studies are required to investigate the physical fitness of English FA Premier League attackers and its influence on game performance.

An interesting finding of the present study is that the maximal running speeds reached during games were 6–8% higher for wide midfielders and attackers than for central defenders. Although the reliability of maximal running speeds were not determined in the present study, it is reasonable to conclude that large differences in maximal running speeds are present between playing positions. For wide midfielders, the maximal running speed may be related to the fact that their high-intensity runs are the longest, giving them more time to reach full acceleration. However, it is also likely that the attackers and wide midfielders have the highest running speeds, as shown by 30- and 40-m sprint tests (Bangsbo, Mohr, & Krustrup, 2006).

Mohr et al. (2003) showed that the amount of high-intensity running decreased after the most intense periods (suggesting a temporary form of fatigue) and decreased markedly towards the end of the game (suggesting a more permanent form of fatigue). The number of players examined in this study was not sufficiently high to allow for differences in playing positions to be elucidated. The present data demonstrate that temporary and permanent decrements in high-intensity running occur for players in all playing positions. The amount of high-intensity running in the most intense period also varied between playing positions but relatively less than the full game, with values of 282, 251, 243, 216, and 182 m, respectively, for wide midfielders, central midfielders, full-backs, attackers, and central defenders. Although the amount of high-intensity running in the most intense 5-min period varied between playing positions, the amount of high-intensity running decreased by around 50% in the subsequent 5 min, reaching values that were 6–8% lower than the game mean. The temporary drop in high-intensity running may have been underestimated, as our results are based on pre-defined 5-min

periods, meaning that the true temporary drop in high-intensity running could have been even greater. These data show the need for a high anaerobic capacity when a large number of high-intensity runs have to be performed within a 5-min period. The amount of high-intensity running in the most intense period of the game has been suggested to be related to the physical capacity of the player, as evaluated in the Yo-Yo IR2 test (Randers, Rostgaard, & Krustrup, 2007). Thus, the present study provides clear evidence of a need for recovery after the most intense periods and physical training aimed at coping with multiple intense actions. Throughout the game, the amount of high-intensity running decreased gradually but the distance deficit for high-intensity running was most pronounced in the last 15-min period of the game, being 18–21% lower for the five playing positions investigated. The decrement in high-intensity running from the first to the last 15-min period was somewhat lower than observed by Mohr et al. (2003). Caution is needed when interpreting the reason for the different findings between studies. However, this difference may be due to the number of matches and players analysed in each study. Mohr et al. (2003) focused on the performance of 18 elite-standard players in both domestic and European games, compared with the 370 elite-standard English League players profiled in the present study. Therefore, as large inter- and intra-player variability in movement patterns are evident from one game to another and within each position, the present study may provide a better picture of the average high-intensity running deficit observed over the duration of the game.

The present study is the first to report mean recovery times between very high-intensity bouts within games and across 5-min periods. From the first to the last 15-min period, recovery times were 28% longer with roughly similar increases among playing positions. The observation that not only the total amount of high-intensity running but also the frequency of high-intensity running bouts decreased may indicate that fatigue manifests over the course of the game and therefore affects the style of play. Players' increased need for recovery and less frequent bouts of high-intensity actions must have impacts on the tactical possibilities of a team and may indicate that players cannot maintain high-intensity running in support of team-mates or covering for them. The high-intensity distance deficit was roughly similar with and without possession of the ball, indicating that all parts of the play are affected by fatigue. It should not be discounted that these observations could also indicate a reduced pace of the game, whereby players reduce the amount of high-intensity running they perform. Despite the present study controlling for various factors (standard of opposition, circadian variation, fixture congestion), caution is necessary when interpreting the results, as the movement patterns of players could be influenced by factors not controlled or measured for (environmental factors, tactical system employed, home advantage, importance of the game, and previous results).

In summary, the present results show that the demands placed on players are high in the modern elite-standard English League and that temporary and permanent decrements occur in high-intensity running. Furthermore, the frequency of high-intensity bouts both with and without ball possession is affected by fatigue and the activity patterns vary between playing positions.

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